

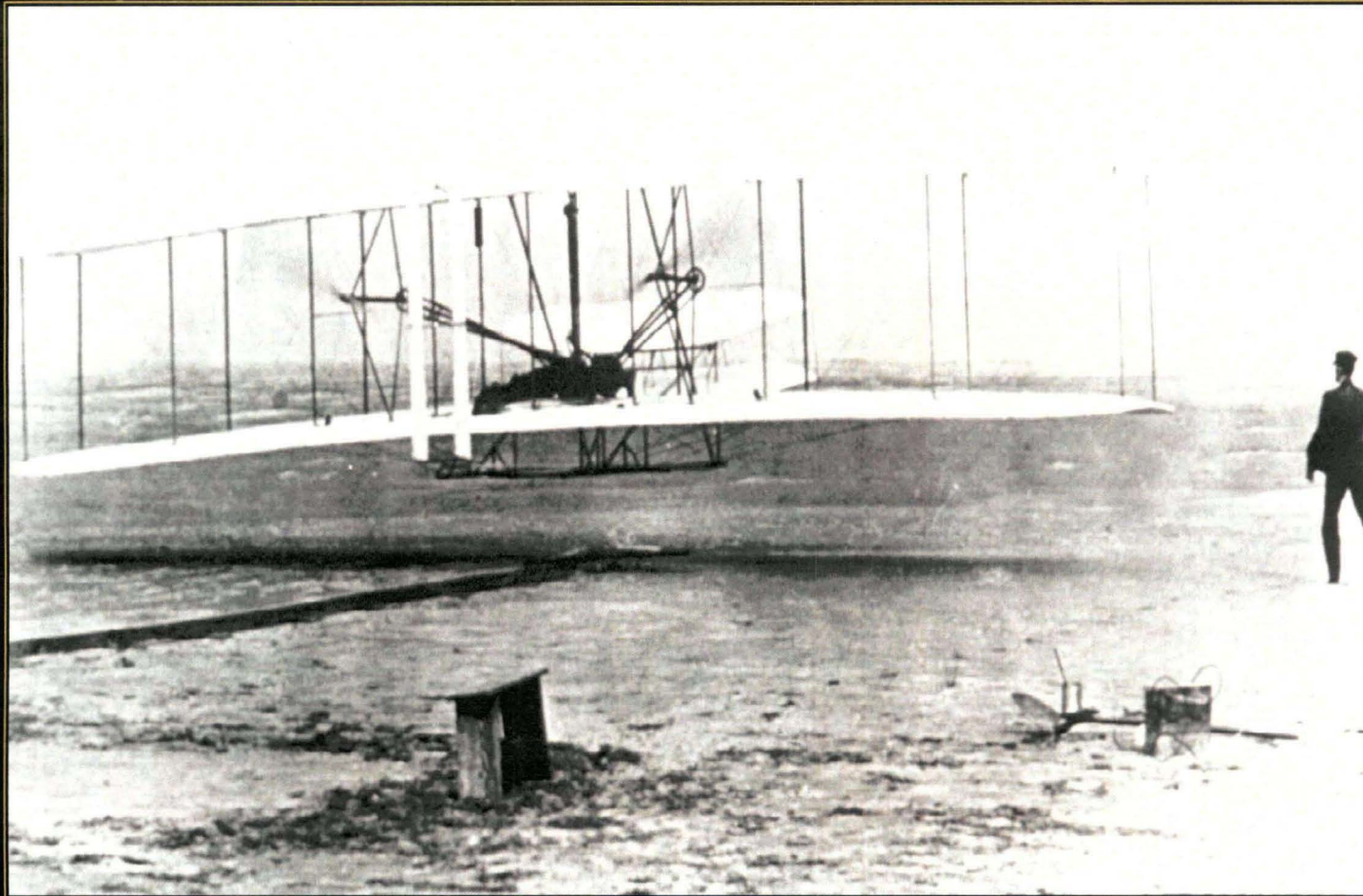
# TRANSITION IN THE HUMAN EXPLORATION OF SPACE AT NASA



Robert Cabana  
Director, Kennedy Space Center



# 1903 – WRIGHT FLYER



1900

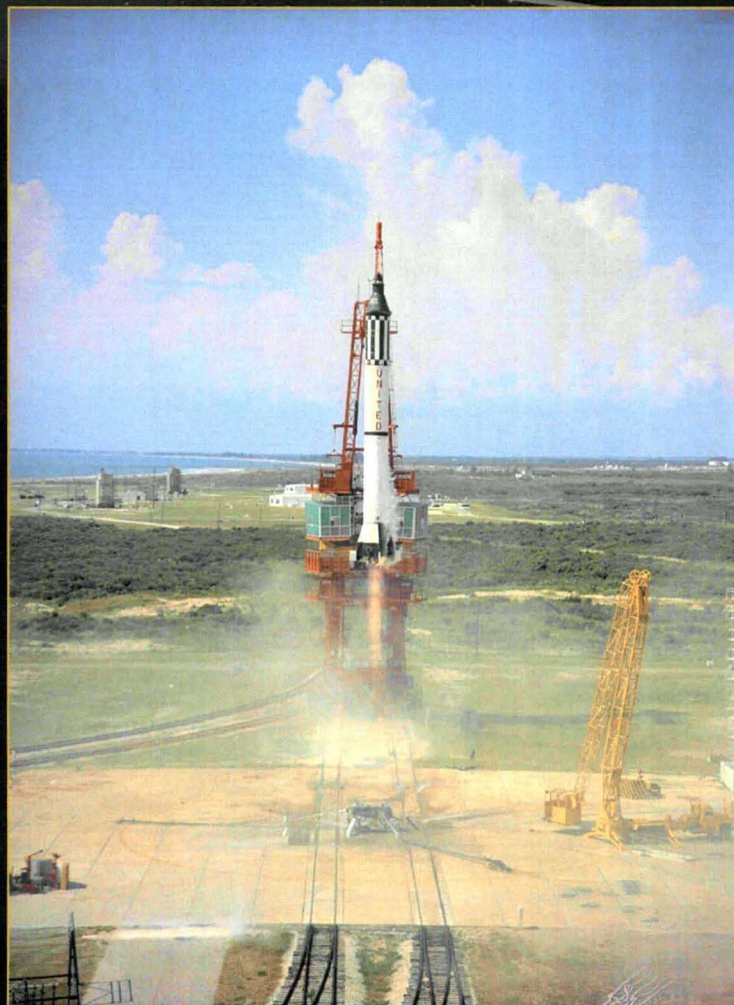
1950

2000

2020



# 1961 – MERCURY – ALAN SHEPHERD



1900

1950

2000

2020



# 1962 – MERCURY-ATLAS – JOHN GLENN



1900

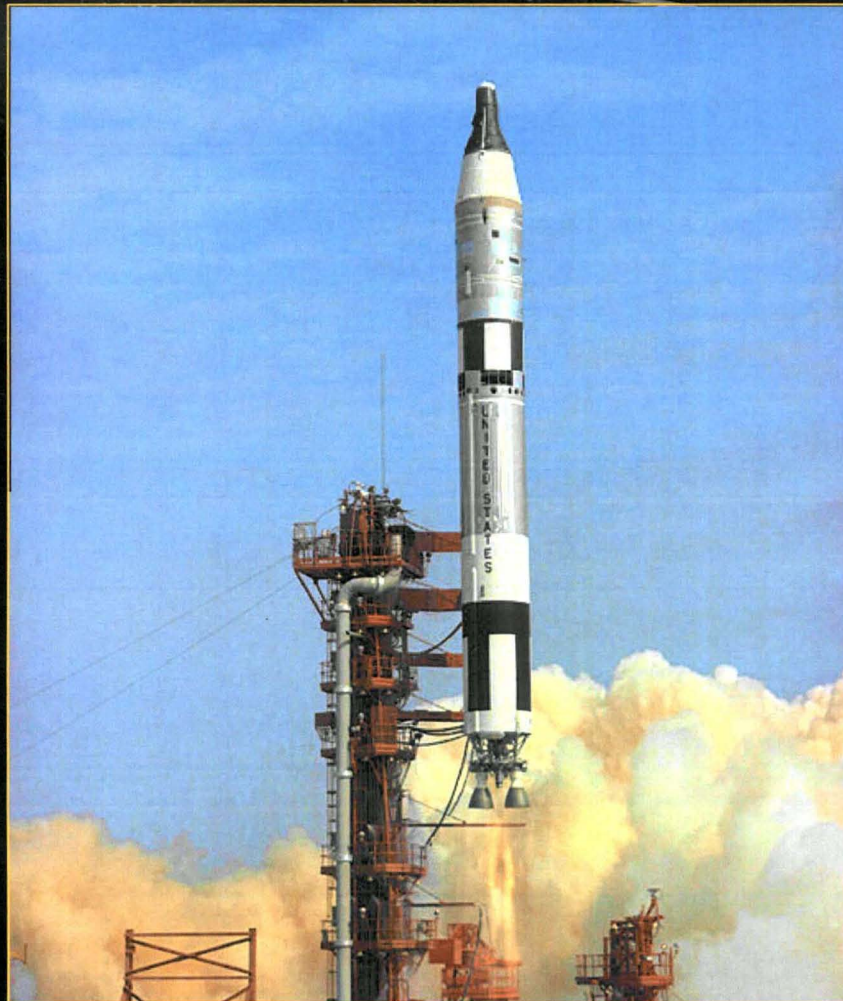
1950

2000

2020



# 1965 - GEMINI



1900

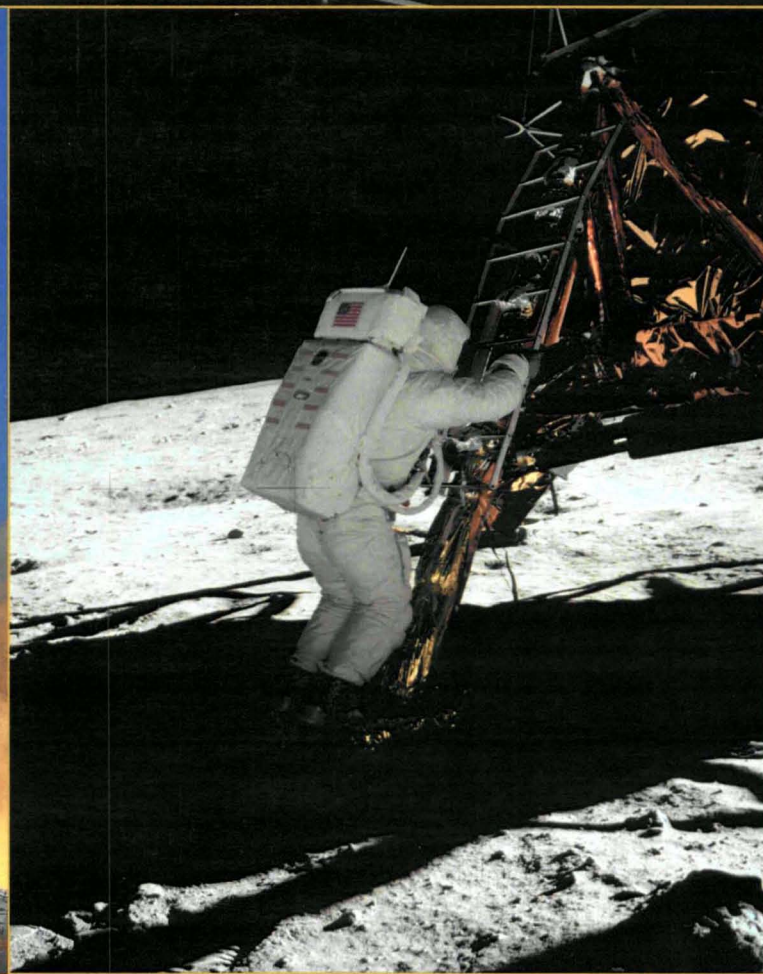
1950

2000

2020



# 1969 – APOLLO 11



1900

1950

2000

2020



# 1973 – SKYLAB



1900

1950

2000

2020



# 1981 – STS-1



1900

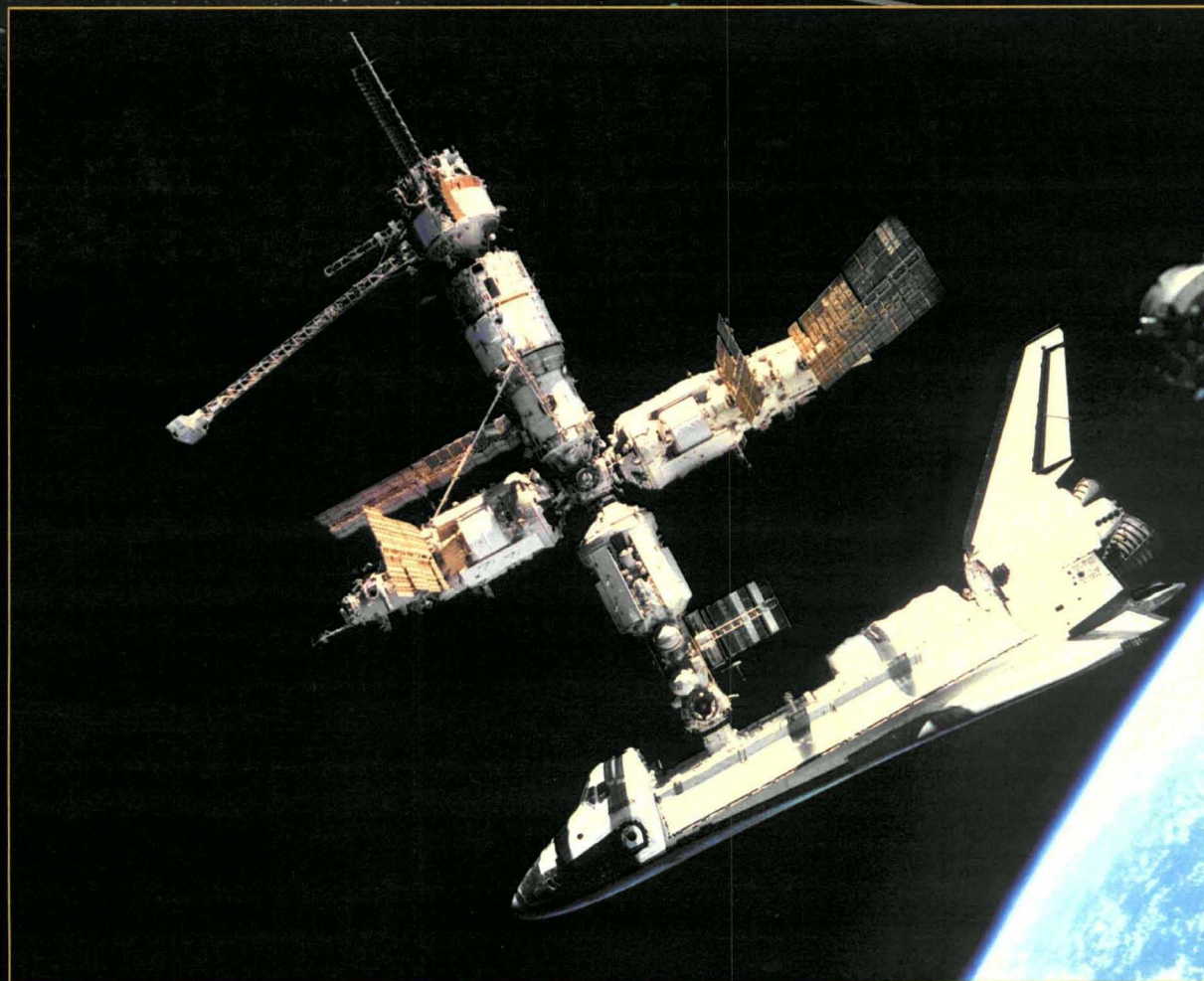
1950

2000

2020



# 1995 – SHUTTLE/MIR



1900

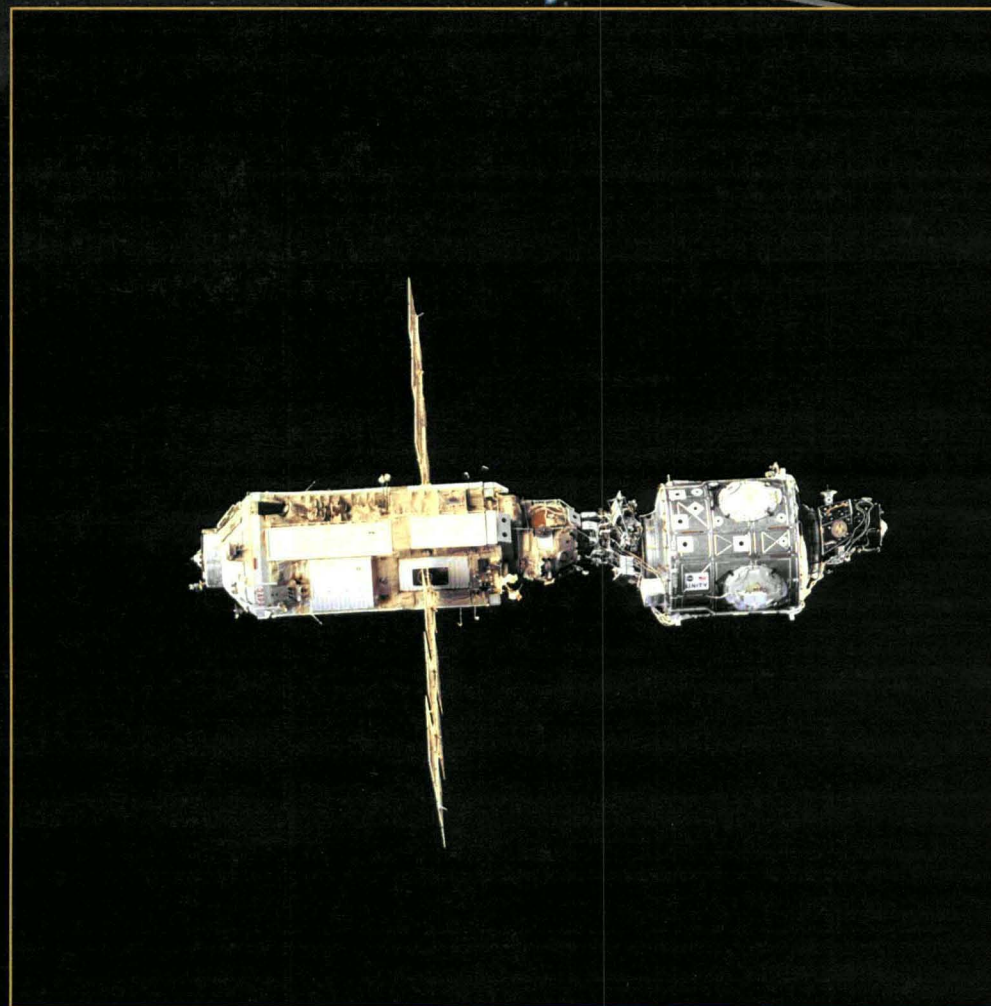
1950

2000

2020



# 1998 – INTERNATIONAL SPACE STATION (ISS)



1900

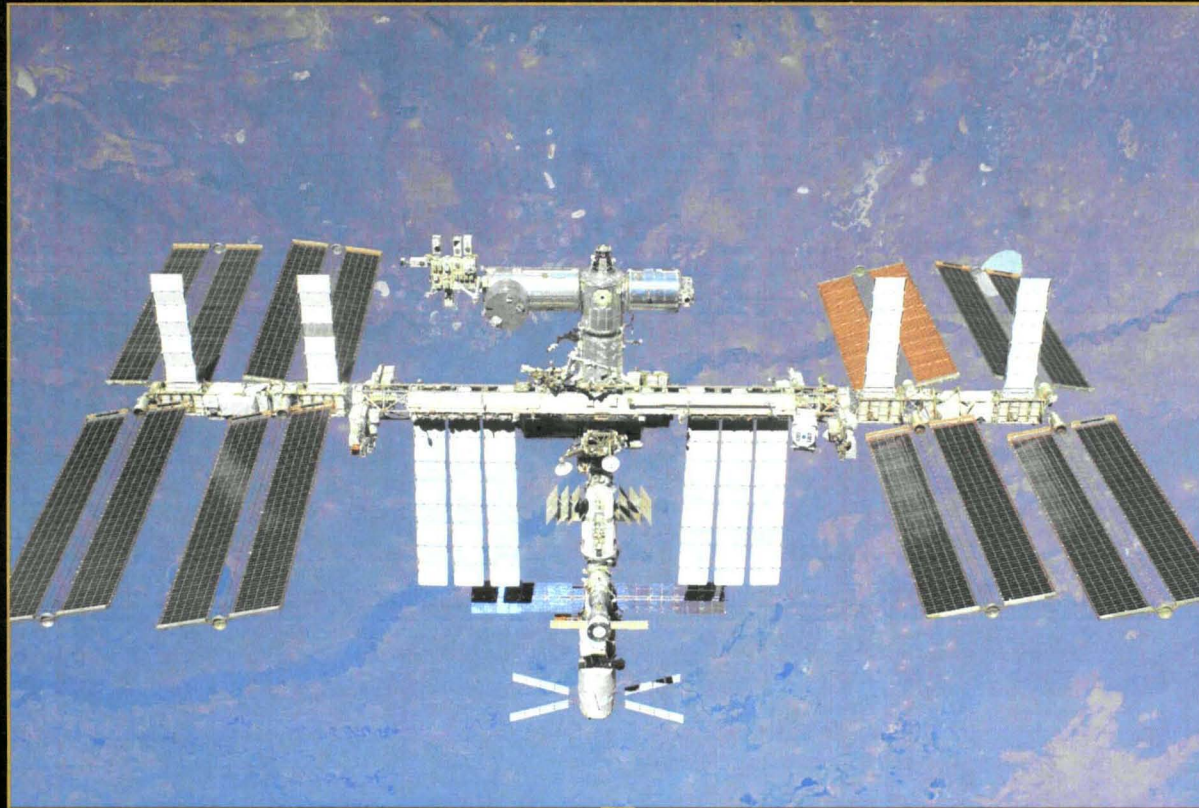
1950

2000

2020



# 2011 – ISS ASSEMBLY COMPLETE



1900

1950

2000

2020



# NASA VISION AND MISSION



- **Vision:** NASA leads scientific and technological advances in aeronautics and space for a Nation on the frontier of discovery
- **Mission:** Drive advances in science, technology, and exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of the Earth



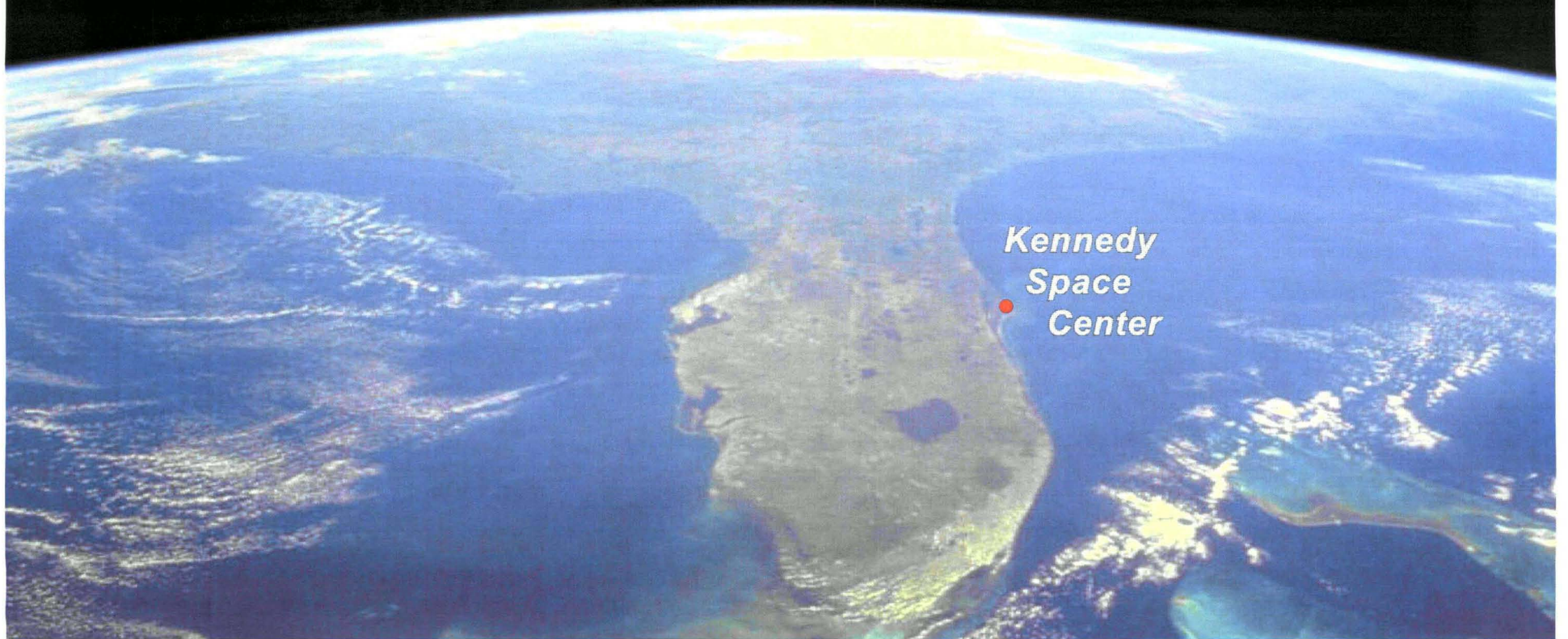
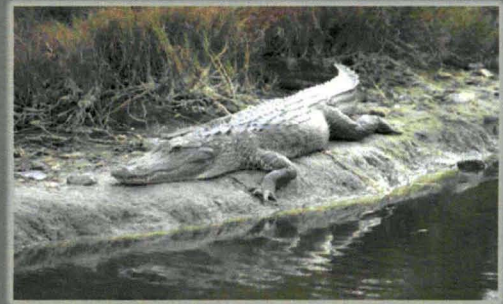
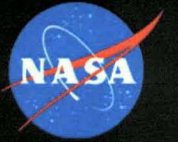


# TEN NASA CENTERS



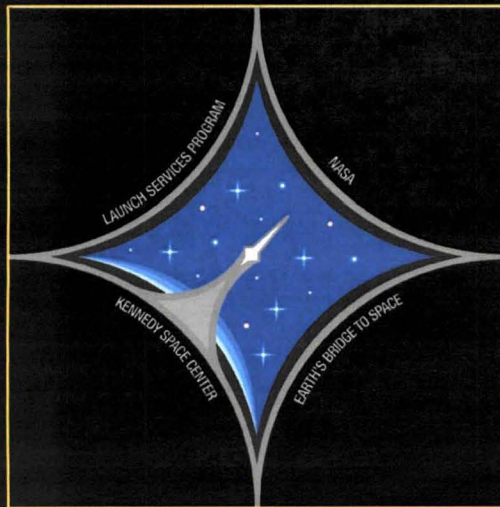


# KENNEY SPACE CENTER (KSC) OVERVIEW





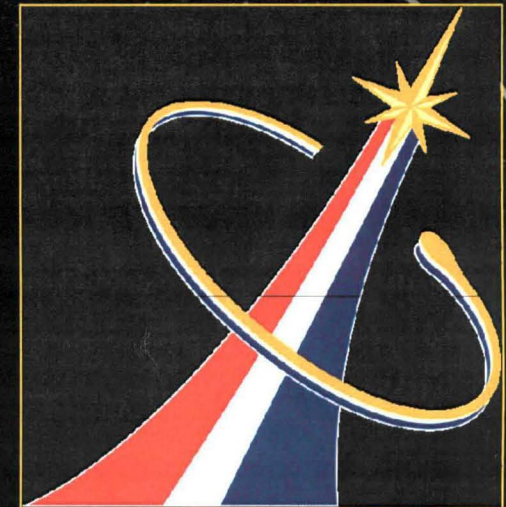
# KSC PROGRAMS



**Launch Services  
Program (LSP)**



**21<sup>st</sup> Century Ground  
Systems Program  
(21CGSP)**

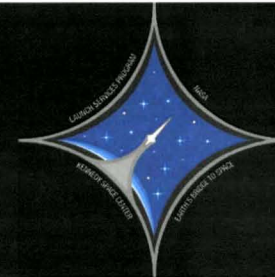


**Commercial  
Crew Program**





# LAUNCH SERVICES PROGRAM (LSP)

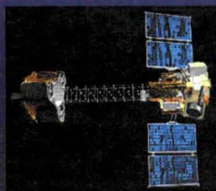


**Mars Science Laboratory (MSL)**  
*Launched November 26, 2011*  
*Arriving at Mars in August 2012*

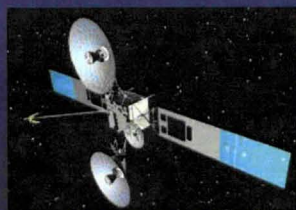




**2012**



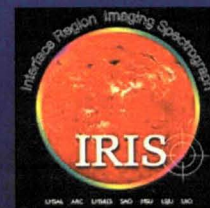
**NuStar - Nuclear Spectroscopic Telescope Array**



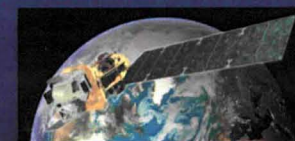
**TDRS K – Tracking and Data Relay System**



**RBSP – Radiation Belt Solar Probes**



**IRIS – Interface Region Imaging Spectrograph**

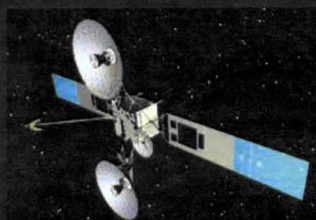


**LDCM – Landsat Data Continuity Mission**

**2013**



**OCO 2 - Orbiting Carbon Observatory**



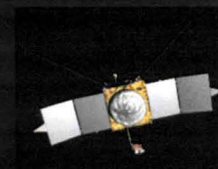
**TDRS L – Tracking and Data Relay System**



**LADEE - Lunar Atmosphere and Dust Environment Explorer**



**GPM - Global Precipitation Measurement**

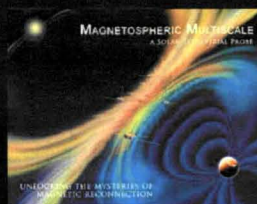


**MAVEN - Mars Atmosphere and Volatile Evolution**

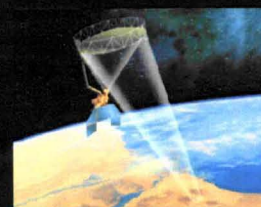
**2014**



**GEMS – Gravity and Extreme Magnetism Small Explorer**



**MMS – Magnetospheric MultiScale**



**SMAP – Soil Moisture Active Passive**



**Jason-3**





# 21<sup>ST</sup> CENTURY GROUND SYSTEMS PROGRAM (21CGSP)



Clean pad  
Flexible Launch Capability



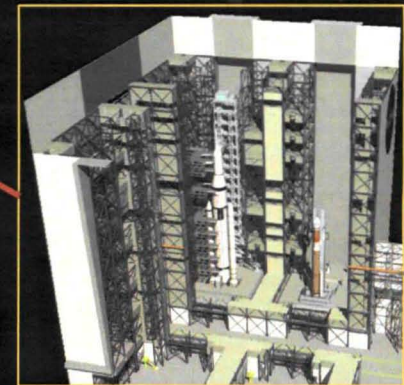
Shuttle pad configuration



OPF-3 Engine Shop



OPF-3

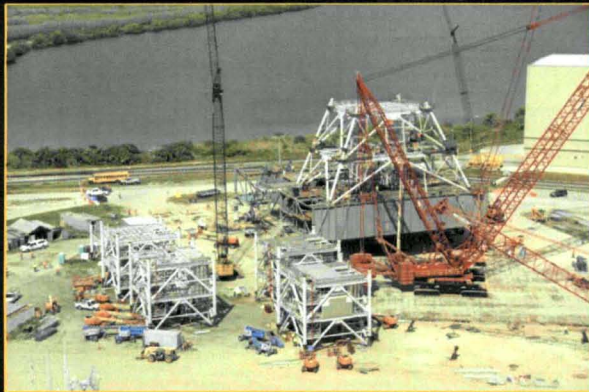


Multi-use Integration (VAB)





# 21CGSP MOBILE LAUNCHER





# SLS DETAILS



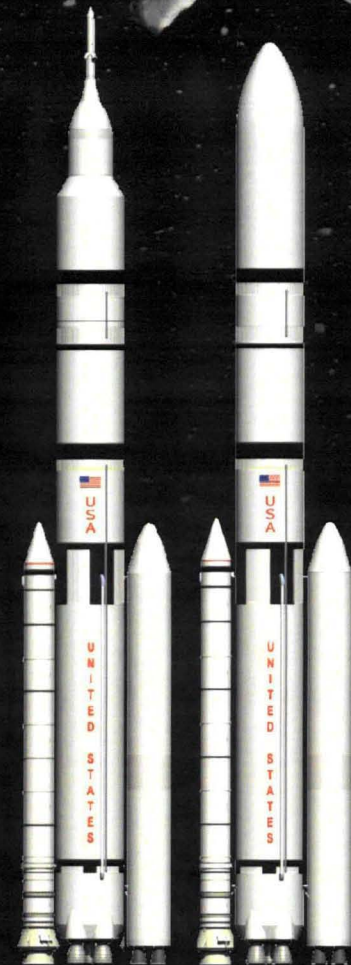
Block 1  
(70t)



Block 1A  
(105t)



Block 2  
(130t)

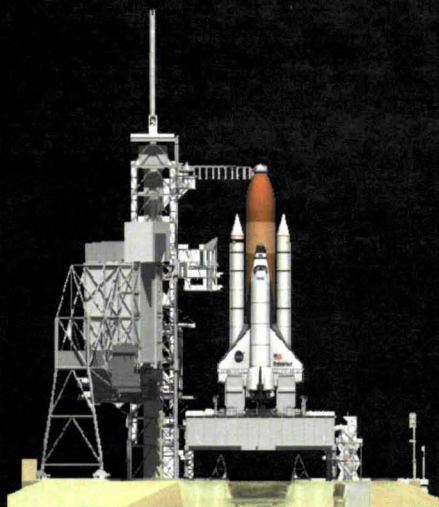




# SPACE LAUNCH SYSTEM (SLS)

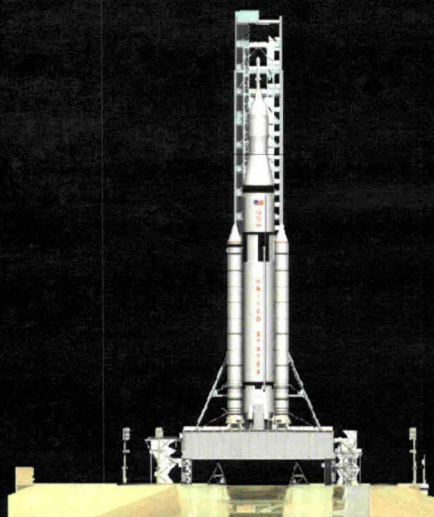


**Space  
Shuttle**



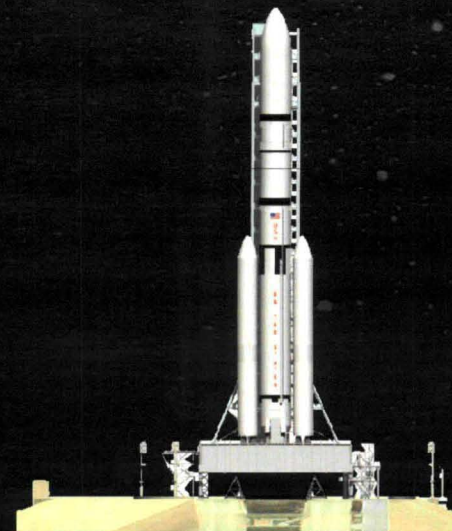
**STS  
LEO 24t**

**Initial  
Design**



**Block 1 / 1A  
LEO 70t -105t**

**Evolved  
Design**



**Block 2  
LEO 130t**

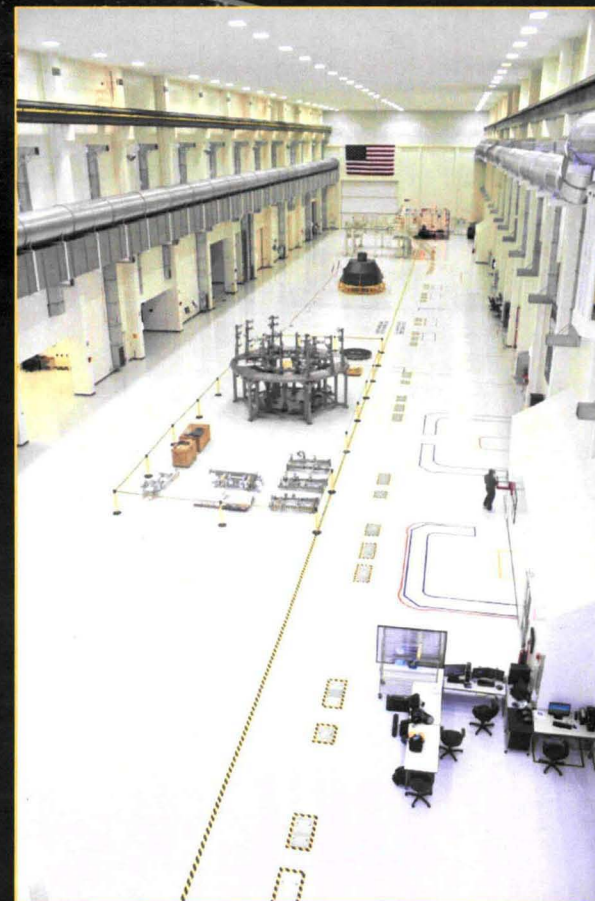




# MULTI-PURPOSE CREW VEHICLE (MPCV)



**Processing in the Operations and Checkout Building at KSC**





# MPCV PAD ABORT TEST



- May 6, 2010
- White Sands Missile Range
- First fully integrated flight test of the launch abort system



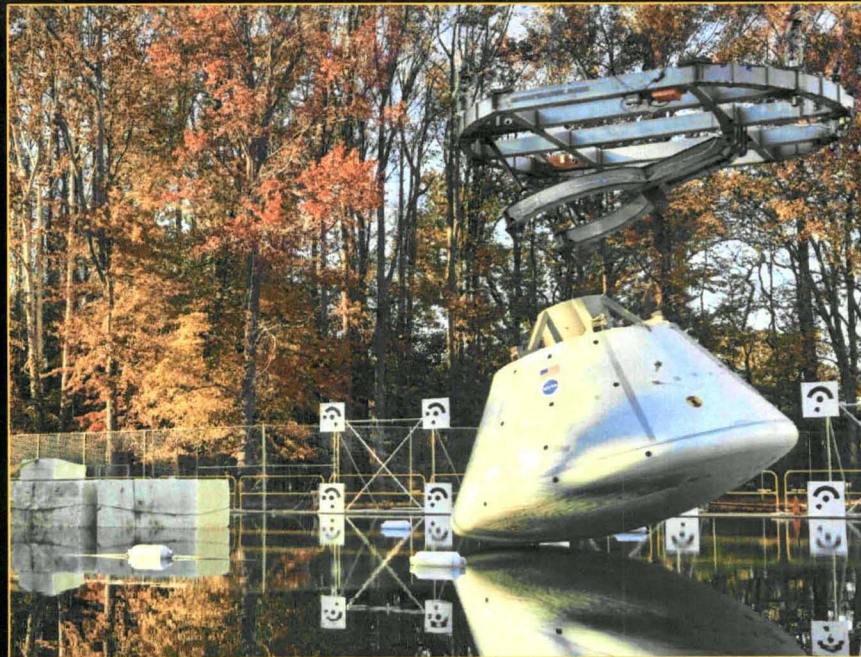


# MPCV PAD ABORT TEST





# MPCV WATER DROP TEST



- NASA's Langley Research Center in Hampton, Virginia
- Simulated water landings





# MPCV WATER DROP TEST





# INCREMENTAL EXPANSION OF HUMAN EXPLORATION CAPABILITIES

Capabilities required at each destination are determined by the mission and packaged into elements. Capability-Driven Framework approach seeks to package these capabilities into a logical progression of common elements to minimize DDT&E and embrace incremental development.

Distance

Long Duration Habitation Needed

Surface Capabilities Needed

Advanced Propulsion Needed

High Thrust in-Space Propulsion Needed

Mission Duration

Lunar Surface Missions

Crew EVA Suit Block 2

Lunar Lander & GPOD

Lunar Flyby & Orbital Missions 33A 33B

GEO/HEO Missions 32A 32B

Cryogenic Propulsion Stage (CPS)

2: Enable Missions Beyond LEO

Robotics & EVA Module (REM)

Crew EVA Suit Block 1

New LEO Missions 31A

Multi-Purpose Crew Vehicle (MPCV)

Space Launch System - HLLV

1: Enable New LEO Missions

3: Enable Lunar Surface Missions

4: Enable Long Duration Missions

Minimal NEA Missions 34A

Deep Space Habitat (DSH)

5: Enable Deep Space Missions

Solar Electric Propulsion (SEP)

Space Exploration Vehicle (SEV)

Full Capability NEA Missions 34B

6: Enable Mars Missions

Mars Elements

Mars Missions 35A 35B

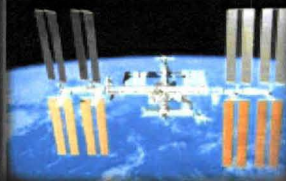
Key

Capability Gates

Candidate Destination

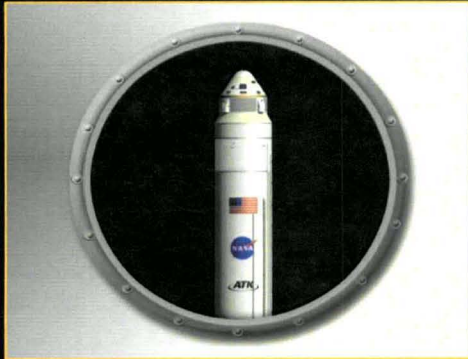
Ultimate Destination Goal

Element Capability





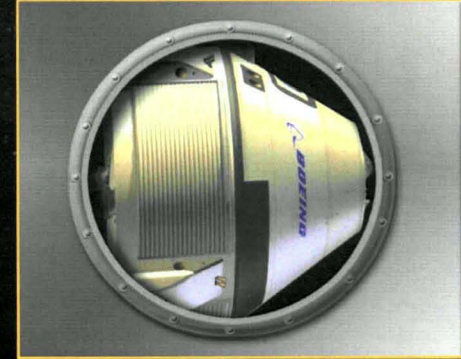
# COMMERCIAL CREW PROGRAM (CCP)



***ATK***



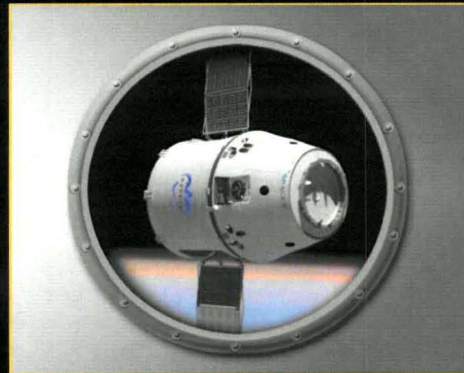
***Blue Origin***



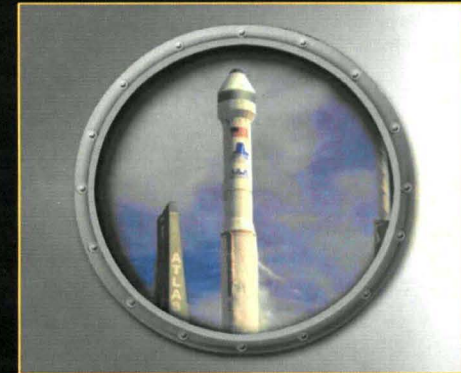
***Boeing***



***Sierra Nevada***



***SpaceX***



***ULA***

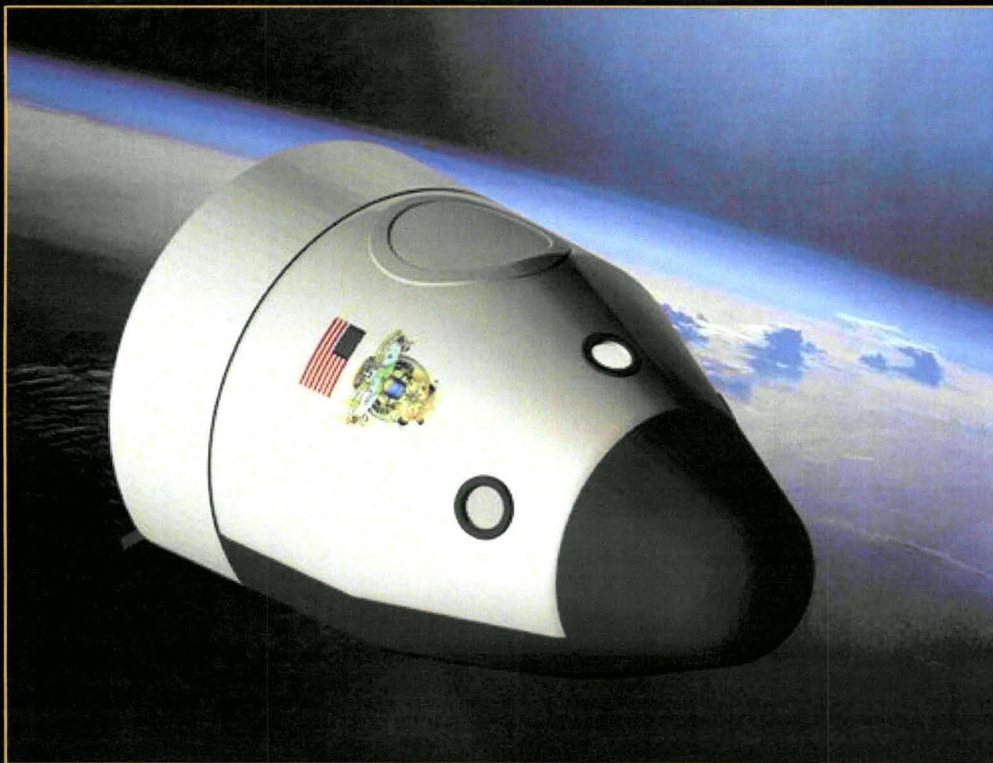




# BLUE ORIGIN



- **Spacecraft:** Reusable biconic Space Vehicle
- **Launch Vehicle:** Reusable Booster System

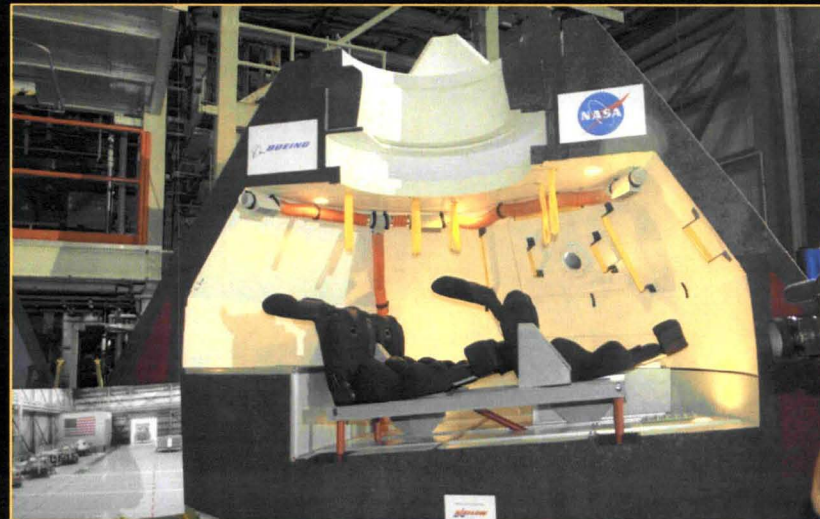
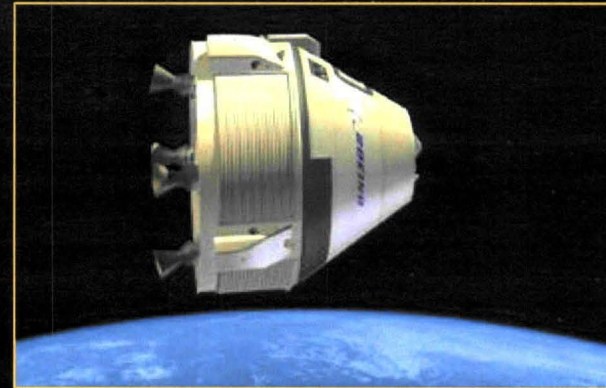




# BOEING

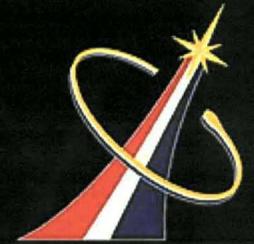


- **Spacecraft:** CST-100
- **Launch Vehicle:** Atlas V

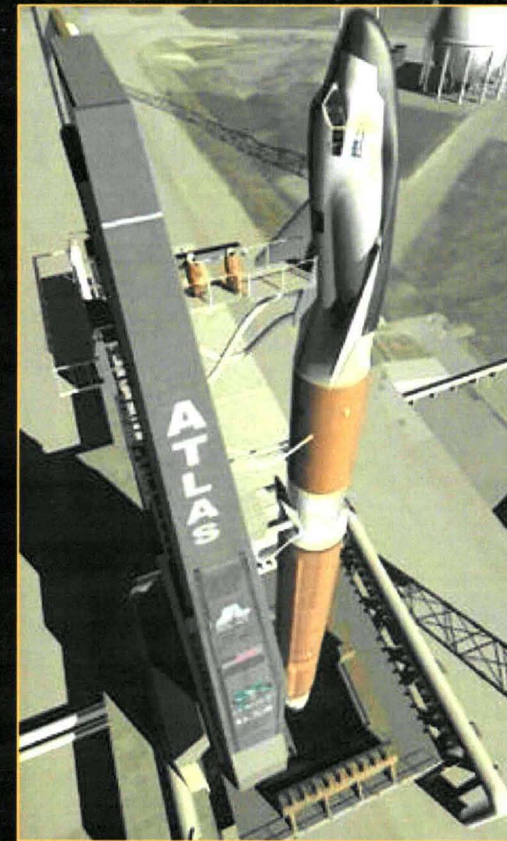
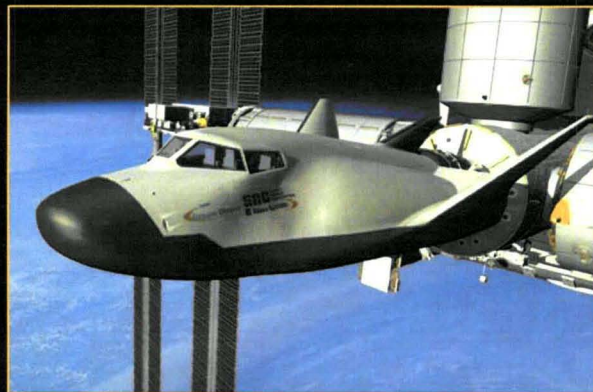




# SIERRA NEVADA CORPORATION



- **Spacecraft:** Dream Chaser
- **Launch Vehicle:** Atlas V

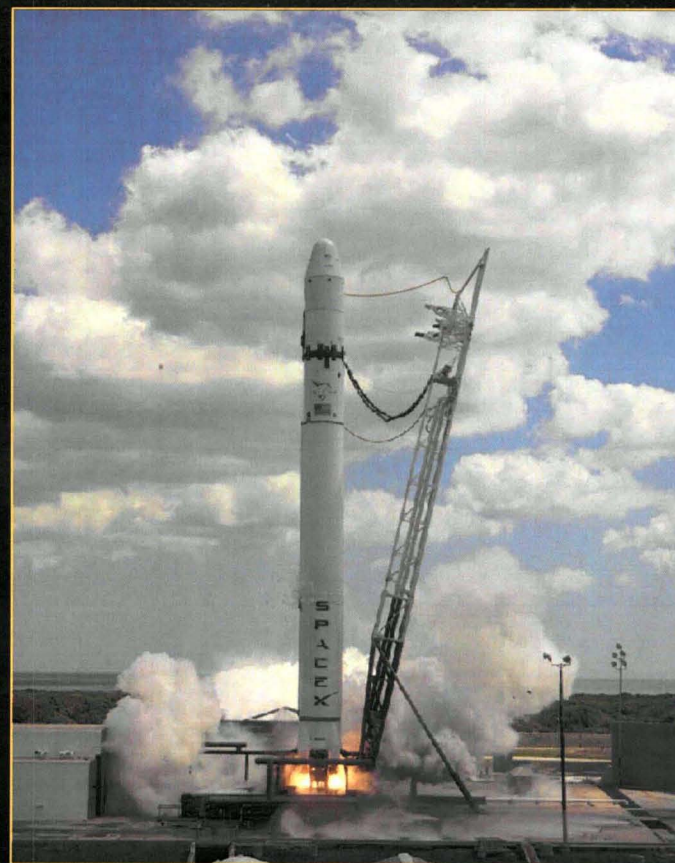




# SPACEX



- **Spacecraft:** Dragon capsule
- **Launch Vehicle:** Falcon 9

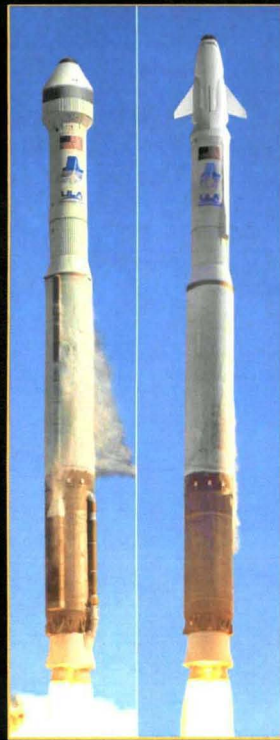




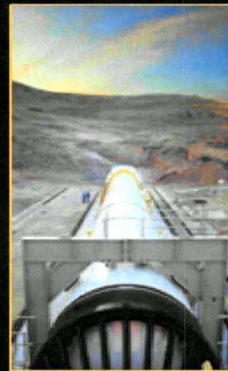
# UNFUNDED SPACE ACT AGREEMENTS



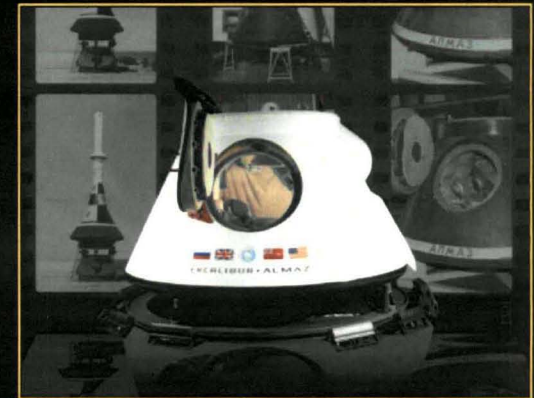
**ULA**



**ATK**

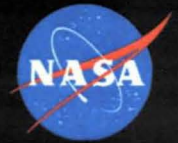


**Excalibur  
Almaz**





# PARTNERING CAPABILITIES



## Center Planning and Development Office

- KSC's "Front Door" to engage new business focusing on:
  - Master plan for KSC infrastructure, land use, and real estate strategies
  - Commercial space transportation and services
  - Retention of highly skilled aerospace workers and facility assets

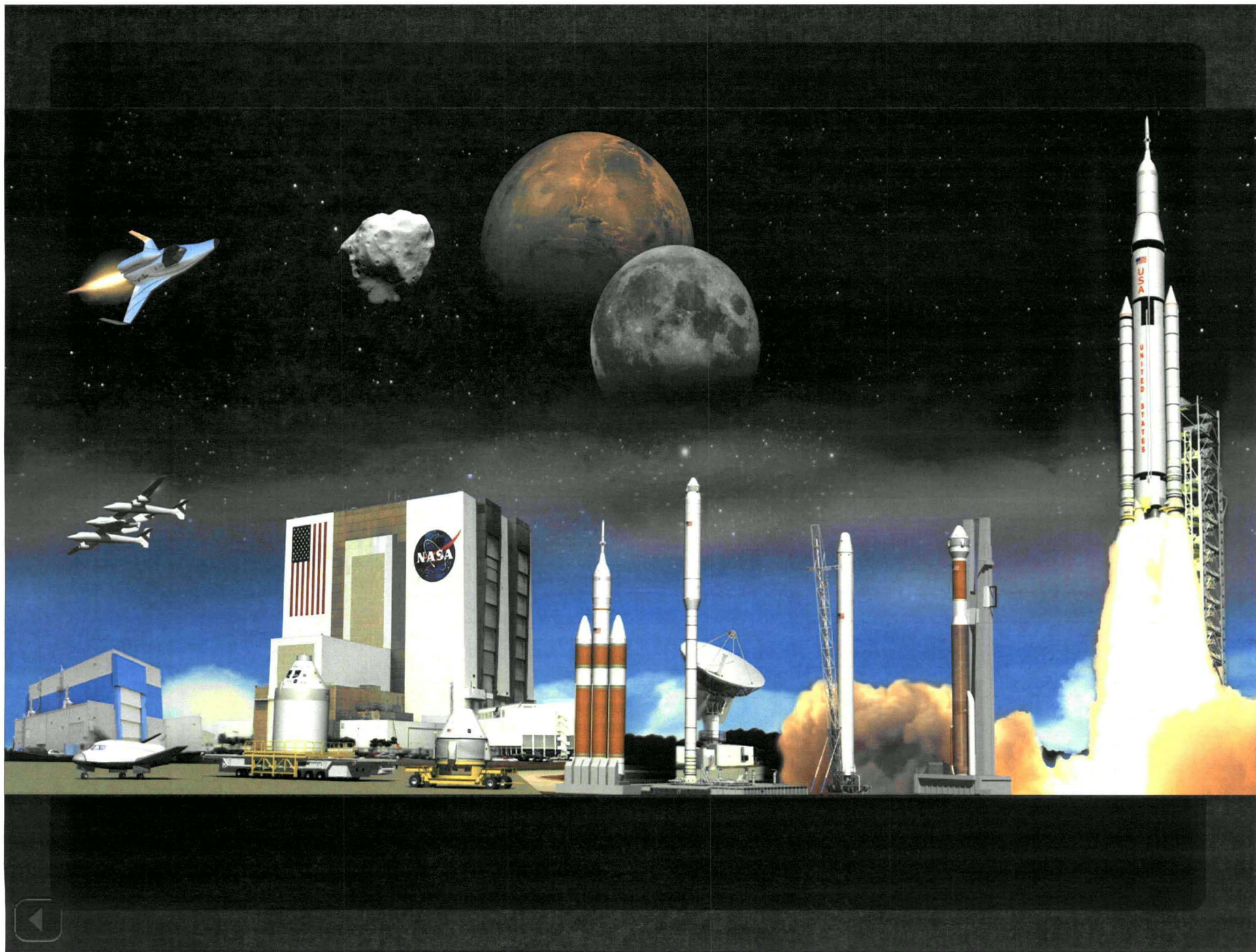




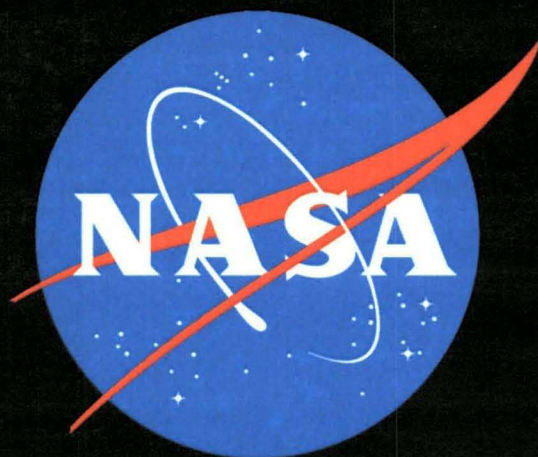
# INTERNATIONAL PARTNERSHIPS













## **Slide 1 - Welcome**

- Thank you for inviting me to be here today representing NASA and the Kennedy Space Center at the Seventh Appleton Space Conference hosted by the Rutherford Appleton Laboratory.
- With the end of the Shuttle Program, NASA is taking the next step in human spaceflight.
- The next NASA program is comprised of the new heavy-lift rocket, the Space Launch System, or SLS, and the crew capsule, the Multi-Purpose Crew Vehicle, which is the Orion capsule.
- We are enabling commercial spaceflight to allow NASA to explore beyond low Earth orbit. This is something we have done for the past 50 years and should be able to develop the requirements for commercial companies to fly to LEO.
- We have had huge success over the past 50 years and are looking forward to the challenges and success over the next 50 years.



## **Slide 2 – 1903 – Wright Flyer**

- Powered flight started on December 17, 1903 with the first flight of the Wright Flyer
- Built by the Wright brothers, the flight took place in Kitty Hawk, North Carolina



### **Slide 3 – 1961 – Mercury – Alan Shepherd**

- First American in space
- May 5, 1961 from Cape Canaveral Air Force Station, Florida on a Mercury-Redstone launch vehicle



#### **Slide 4 – 1962 – Mercury-Atlas – John Glenn**

- First American to orbit the Earth
- February 20, 1962 from Cape Canaveral, Florida on a Mercury-Atlas launch vehicle



## **Slide 5 – 1965 – Gemini**

- First Gemini program launch – Gus Grissom and John Young
- March 23, 1965 on a Gemini-Titan launch vehicle



## **Slide 6 – Apollo 11**

- First manned Moon Apollo launch – October 11, 1968
  - First manned launch on the Saturn IB and the first three-man American space mission
  - Walter Schirra, Donn Eisele, and Walter Cunningham
- Apollo 11 launched on July 16, 1969
  - Neil Armstrong, Buzz Aldrin, and Michael Collins
  - Saturn V launch vehicle
- First man on the Moon – Neil Armstrong, landed July 21, 1969



## **Slide 7 – 1973 - Skylab**

- Skylab was launched unmanned on a modified Saturn V rocket
- 3 manned missions went to the station between 1973 and 1974 atop a Saturn IB



## **Slide 8 – 1981 – STS-1**

- First launch on April 12, 1981 with John Young and Bob Crippen on Columbia



### **Slide 9 – 1995 – Shuttle/Mir**

- First docking of the Space Shuttle to Mir occurred on June 29, 1995 on STS-71 by Atlantis
- A total of 11 Shuttle flights were made to Mir with 9 dockings



## **Slide 10 – 1998 – International Space Station (ISS)**

- The first assembly mission to the ISS occurred during STS-88, which launched on December 4, 1998.



### **Slide 11 – 2011 – ISS Assembly Complete**

- The International Space Station was completed earlier this year.
- It took 15 countries, 13 years to complete assembly.
- The flags shown are the countries that signed the agreements for the International Space Station.
  - Canada, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, Japan, Russia, and the United States
- Without this cooperation between nations, the Station would not exist.



## **Slide 12 – NASA Vision and Mission**

- As we move into the future of human exploration, the vision of NASA is to lead the scientific and technological advances in aeronautics and space for a Nation on the frontier of discovery.
- Our mission is to drive advances in science, technology, and exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of the Earth.
- We will do this by accomplishing our goals:
  - Goal 1: Extend and sustain human activities across the solar system.
  - Goal 2: Expand scientific understanding of the Earth and the universe in which we live.
  - Goal 3: Create the innovative new space technologies for our exploration, science, and economic future.
  - Goal 4: Advance aeronautics research for societal benefit.
  - Goal 5: Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.
  - Goal 6: Share NASA with the public, educators, and students to provide opportunities to participate in our mission, foster innovation and contribute to a strong National economy.



### **Slide 13 – Ten NASA Centers**

- To accomplish our mission and vision, we have 10 Centers performing work across the country and specializing in different areas.
- Dryden Flight Research Center - their mission is to advance technology and science through flight. They perform flight research and technology integration, validate space exploration concepts, and conduct airborne remote sensing and science missions.
- Ames Research Center – provides leadership in astrobiology, small satellite, robotic lunar exploration, technologies for exploration, search for habitable planets, supercomputing, intelligent/adaptive systems, advance thermal protection, airborne astronomy.
- Johnson Space Center – home of the astronaut corps, leads NASA's flight-related scientific and medical research efforts, manage the development, testing, production and delivery of all U.S. human spacecraft, and all human spacecraft-related functions.
- Stennis Space Center – has served as NASA's primary rocket propulsion testing ground for more than four decades.
- Glenn Research Center – researches, designs, develops and tests innovative technology for aeronautics and spaceflight.
- NASA HQ – provides overall guidance and direction to the agency, under the leadership of the Administrator. Three Mission Directorates: Aeronautics, Human Exploration and Operations, and Science.
- Goddard Space Flight Center – home to the nation's largest organization of combined scientists, engineers and technologies that build spacecraft, instruments and new technology to study the Earth, the sun, our solar system, and the universe.
- Langley Research Center – study the atmosphere to improve life on Earth and better understand the conditions planes and spacecraft fly through. Work on technologies to make civilian and military planes safer, quieter, and more efficient, while designing tomorrow's supersonic and hypersonic aircraft. Houses majority of NASA's wind tunnels.
- Marshall Space Flight Center – provides multidiscipline engineering expertise behind propulsion and transportation systems, continues to enable scientific discovery through development of hardware and instruments, develops, integrates, and operates major components and systems on the ISS and supports operations around the clock.
- While the Centers are only located in 8 of the 50 states, each state contributes something to NASA. For example, the Space Shuttle was built with parts from 48 of the 50 states.



## **Slide 14 – Kennedy Space Center (KSC) Overview**

- At KSC, we have been the launch site for every US human space flight since 1968 and we will be celebrating our 50th anniversary next summer.
  - Launches from 1961 to 1967 were conducted next door from the Cape Canaveral Air Force Station.
- Kennedy Space Center covers approximately 140,000 square acres adjacent to the Cape Canaveral Air Force Station and is located within the confines of the Merritt Island National Wildlife Refuge and the Canaveral National Seashore. This unique location helps to promote environmental awareness and stewardship.
- Of those 140,000 acres, only 6,800 are used for NASA-related activities.
- The remaining land is federally protected in an effort to safeguard the wildlife that is living here.
- The preserve is home to 150 species of fish, 69 species of reptiles and amphibians, 267 species of birds, and 30 species of mammals. Within these species, we have 27 state and federally protected species that live on the preserve. 11 of these are federally listed as threatened or endangered – such as the West Indian Manatee, Florida Scrub Jay, and the Kemps Ridley Sea Turtle.
- There are also 13 bald eagle nests across the center, including the one along one of the main roads.
- We have worked harmoniously with the wildlife during mission processing for the Shuttle, ISS and the Launch Services Program and will continue to do so in the future.

## **Slide 15 – KSC Programs**

- As I mentioned earlier, while the end of the Space Shuttle Program has been hard for all of us, it certainly does not mean the end of NASA.
- We have a very bright future and KSC is playing an important role in the future of human spaceflight.
- At KSC, we have traditionally been an operations Center with one program office, the Launch Services Program (LSP).
- LSP processes payloads for NASA science missions, and others, that use expendable rockets.
- Their expertise is invaluable, especially now that KSC has added two new programs – the Commercial Crew Program and 21st Century Ground Systems Program (21CGSP).
- These are two of the new programs associated with the future of human spaceflight. NASA also has the Space Launch System, run out of the Marshall Space Flight Center, and the Multi-Purpose Crew Vehicle, or Orion, Program run out of Johnson Space Center.
- The Commercial Crew Program is benefitting from LSP's experience by using the LSP model for Systems Engineering & Integration (SE&I) analysis, insight, and certification process.
- Individuals from LSP are now part of the Commercial Crew office. Having experienced resources in-house provided guidance on commercial areas including the Commercial Orbital Transportation System (COTS) Program.
- The Commercial Crew Program is designed to manage commercial space activities that will develop and demonstrate human spaceflight capabilities.
- Our goal is to turn over transportation to low-Earth orbit to our commercial partners, freeing NASA to explore the outer depths of our solar system.
- The 21st Century Ground Systems Program is responsible for modernizing our facilities to accommodate multiple commercial and government customers, especially for the SLS and MPCV.
- All of us at KSC are committed to making these programs successful. The growth and achievements of these programs will likely result in significant expansion in the Space Coast's space industry.



## **Slide 16 – Launch Services Program**

- Our Launch Services Program acts as a broker to match the payload with a specific rocket in order to ensure mission success.
- They have launched 67 missions to date with over 35 future missions planned.
- Their final launch for this year was the Mars Science Laboratory (MSL) launched on November 26th on an Atlas V from Cape Canaveral, Florida.
  - The Curiosity rover is the size of a Volkswagen Beetle.
  - After it lands next August, MSL will assess the planet's environment and determine if it is, or was habitable – whether the environment can support microbial life.
  - When this lands on Mars, it will be one of the neatest landings we have performed. The parachute will deploy and slow the capsule (seen in the photo on the right) down before firing thrusters to hover over the ground. The rover will lower down on a cable and after the rover is on the ground, the cable will be severed before the descent stage flies off and crash-lands away from the rover.
  - MSL will have the ability to travel further than other rovers, and tell us more about the planet than previously known.

## Slide 17 – LSP Launch Manifest

- LSP has several launches over the next three years and the schedule starts next year with a launch in February out of the Kwajalein Atoll.
  - NuSTAR is a two-year mission that will deploy the first focusing telescopes to image the sky in the high energy X-ray (6 - 79 keV) region of the electromagnetic spectrum.
- Several of these missions also have international cooperation.
  - The IRIS mission launching in 2012, has 20 partners working together, including:
    - The Institute for Theoretical Astrophysics at the University of Oslo
    - NASA Ames Research Center
    - NASA Goddard Space Flight Center
    - Sydney Institute for Astronomy, University of Sydney
    - Center for Plasma Astrophysics, University of Leuven
    - Mullard Space Science Laboratory
    - European Space Agency
    - National Astronomical Observatory, Tokyo
    - Niels Bohr Institute, University of Copenhagen
    - **Rutherford-Appleton Laboratory**
  - In 2013, NASA is working with JAXA on the GPM (Global Precipitation Measurement)
  - And in 2014, Jason 3 has CNES (Centre National d'Etudes Spatiales, Paris), EUMETSAT (European Organization for the Exploration of Meteorological Satellites), NASA, JPL (Jet Propulsion Lab), NOAA (National Oceanic and Atmospheric Administration) working together.
- LSP has over 13 years of experience procuring, managing, and launching commercial launch vehicles and as you can see, the next few years will be busy.
- The commercial crew program is leveraging off of the successful LSP to best fit the needs and requirements of the Agency to get crew safely to low earth orbit.
- Each program being co-located at KSC affords the agency the maximum amount of synergy across each of these two programs.
- This will enable KSC to be the lead center for the agency for human space flight.



## **Slide 18 – 21<sup>st</sup> Century Ground Systems Program (21CGSP)**

- KSC has traditionally been a one-system launch complex and was dedicated to Shuttle. That is changing.
- Our 21st Century Ground Systems Program (21CGSP) is responsible for modernizing our facilities to accommodate multiple commercial and government customers and transforming our infrastructure into a multi-user spaceport. A multi-use approach will allow the right fit for the right mission, launch, vehicle, and manifest. We are trying to be as flexible and generic as possible.
- Updating our facilities allows us to support NASA's goal of exploring beyond LEO with an evolvable heavy lift vehicle (SLS) and crew capsule (MPCV), while enabling commercial space.
- Many of the tasks being done to update the infrastructure are those that can't be seen. While it seems like Launch Complex 39B is simply being demolished as the Rotating Service Structure (RSS) and Fixed Service Structure (FSS) are removed, underneath the surface it looks brand new. All of the copper wire has been removed and replaced with fiber optics. We made \$621,000 from the scrap copper wire.
- Investments in the 21CGSP focus on the ground system development required to support SLS and MPCV while also leveraging common system infrastructure for other government and commercial users.

## **Slide 19 – 21CGSP Mobile Launcher**

- The mobile launcher was originally designed for the Constellation Program and the Ares rockets.
- With the cancellation of Constellation, we pressed forward with construction and completed the structure in 2010.
- Originally envisioned to host a slim rocket, the structure's design was flexible enough that it can be modified to support the Space Launch System, or SLS.
- The dominate feature is the mobile launcher's tower, a 355-foot high gray, steel tower reminiscent of the ones that serviced the Saturn V rockets headed to the moon in the 1960s and 70s.
- The tower was built atop a 47-foot-tall base of steel that is 165 feet long and 135 feet wide. Weighing in at 6.75 million pounds.
- The modifications to come include strengthening the supports in the base and widening the exhaust port the rocket will stand over. The ML's exhaust port now is a 22-foot square, but it will be enlarged to a 60-foot by 30-foot rectangle.
- Swing arms will be added to the tower in the 2015 time frame to provide fueling and venting, along with electrical and communication link, o the different stages of the rocket. A crew access arm also will be added to reach out the NASA's new Orion spacecraft at the top of the rocket.
- All testing for these elements will take place at KSC at the Launch Equipment Test Facility. The laboratory is built to allow full-size segments of ground support equipment be evaluated under realistic conditions.
- Once the ML has been outfitted with its swing arms and other modifications are complete, it will be taken to the pad for additional testing.
- The ML will be used to carry the SLS to the pad in 2017, ahead of the rocket's first test mission.



## **Slide 20 – Space Launch System (SLS)**

- The Space Launch System is NASA's new heavy-lift rocket.
- It will provide an entirely new capability for human exploration beyond Earth orbit. It will also back up commercial and international partner transportation services to the International Space Station.
- As you can see from this comparison, it is quite a bit larger than the Shuttle.
- It is an evolvable vehicle that will have an initial lifting capacity of 70 metric tons, more than double any operational vehicle today, and eventually have a lifting capability of 130 metric tons. This is more than any past or present vehicle.
- Designed to be flexible for crew or cargo missions, the SLS will be safe, affordable, and sustainable, to continue America's journey of discovery from the unique vantage point of space.
- In the crew configuration, the SLS will transport the Multi-Purpose Crew Vehicle to entirely new destinations beyond Earth orbit, continuing America's human exploration of space.
- It will also be able to carry cargo, equipment, and science experiments to destinations beyond Earth-orbit.

## **Slide 21 – SLS Details**

- The SLS will take advantage of Shuttle-heritage hardware.
- It will use a liquid hydrogen and liquid oxygen propulsion system, where Space Shuttle Main Engines (RS-25) in stock will provide the core propulsion and the J-2X engine, now in testing, is planned for use in the upper stage as the vehicle is evolved.
- Using the same fuel system for the core and the upper stage reduces costs and leverages U. S. state-of-the-art technologies.
- Five-segment solid rocket boosters, now in testing, will be used for the initial flights, while advanced boosters will be competed for the evolved capability.
- As the vehicle evolves, so will the destinations.
- Block 1 will be able to travel to the ISS, as a backup for commercial providers and international partners, as well as the Moon.
- Block 1A will be able to travel to the Moon and a Near Earth Asteroid.
- And Block 2 will be the rocket that will get us to a Near Earth Asteroid and Mars.



## **Slide 22 – Multi-Purpose Crew Vehicle (MPCV)**

- The Multi-Purpose Crew Vehicle, also known as Orion, is the next generation spacecraft for human space exploration. It is comprised of the Launch Abort System (LAS), Crew Module (CM), and Service Module (SM).
- The LAS, positioned on a tower atop the CM, activates within milliseconds to propel the crew module to safety in the event of an emergency during launch or climb to orbit. The system also protects the CM from dangerous atmospheric loads and heating.
- The crew module is the transportation capsule that provides a safe habitat for the crew, provides storage for consumables and research instruments, and serves as the docking port for crew transfer.
- The final component is the SM, which supports the crew module from launch through separation prior to reentry. It provides in-space propulsion capability for orbital transfer, altitude control, and high altitude ascent aborts. When mated with the crew module, it provides the systems needed for a habitable environment, generates and stores electrical power while on-orbit, and maintains the temperature of the vehicle's systems and components.
- Lockheed Martin (LM) was selected to build Orion and will perform final assembly, checkout, and acceptance testing of Orion for both the CM and the SM at KSC in the Operations and Checkout Building High Bay. This is the same High Bay that processed the Apollo capsules that went to the Moon.
- Renovations were completed in 2009 in the O&C High Bay to include, portable tooling stations, 90,000 square feet of air-bearing floor space and specially designed air-bearing pallets, and a portable clean room system.
- NASA recently announced plans for the first Exploration Flight Test (EFT-1) of the MPCV in early 2014, to support the SLS. The test will acquire critical re-entry flight performance data and demonstrate early integration capabilities that benefit the MPCV, SLS, and 21st Century Ground Systems programs. They have even started building the EFT-1 vehicle.
- To date, LM has already completed critical subsystem tests and production milestones to meet these flight test objectives, such as completion of the first Orion CM, pad abort flight test and other subsystem tests, to name a few. The Orion team has already completed a series of structural, acoustic and vibration tests. Once complete with these tests, the vehicle will be sent to NASA's Langley Research Center for a series of landing tests at the new Hydro Impact Basin.

## **Slide 23 – MPCV Pad Abort Test**

- On May 6, 2010, Orion completed its first successful flight test of the launch abort system at the White Sands Missile Range.
- Test Objectives:
  1. Demonstrate full-scale LAS pad abort performance
  2. Verify in-flight loads and environments
  3. Demonstrate escape capability of the LAS
  4. Demonstrate abort event sequencing
- The 55.5-foot-tall launch abort vehicle and crew module mock-up, reached a speed of about 445 miles per hour in only three seconds.
- This was a 97-second test and had an initial 500,000-pound blast of solid rocket motor thrust.
- More than 600 measurements were taken real-time during the test, providing data only gained through early test flights.
- Technology firsts incorporated into the LAS design include: a new reverse-flow, high-thrust, human-rated rocket motor and the largest and only human-rated controllable solid rocket motor.
- The abort motor with revolutionary reverse flow nozzles, pulls the Orion capsule away from the launch vehicle, something America has never built before and the first to be human-rated.
- The attitude control motor provides directional control for the vehicle, the first-time a solid rocket motor has been designed to vector, steer and control. The attitude control motor provides directional control for the jettison motor, which separates the crew module from the LAS so that parachutes can deploy for a safe landing.
- I'd like to share a video of this test with you.



**Slide 24 – MPCV Pad Abort Test – VIDEO**

## **Slide 25 – MPCV Water Drop Test**

- Engineers started Phase 1 of the Orion MPCV boilerplate test article at NASA's Langley Research Center on October 18<sup>th</sup> of this year.
- Modifications to the test article included removal of the Phase 0 reinforcement structure to configure the heat shield to now be flexible instead of rigid. The change in heat shield configuration will allow engineers to assess structural response of the heat shield structure versus analytical predictions, and to simulate the flight vehicle load paths to assess load distribution throughout the test article due to water impact.
- The water drop test studies the effects of the capsule dropping at varying pitch angles and roll angles and allow engineers to predict the conditions in different landing conditions.
- Testing is taking place at Langley's Hydro Impact Basin, completed in January of this year. It is 115-feet long, 90-feet wide, and 20-feet deep, and will be used to validate and certify space vehicles, such as the Orion crew module, for safe water landings.
- Three tests have taken place so far, including simulating an abort landing and a safe landing.
- I have another video showing one of these water tests.



## **Slide 26 – MPCV Water Drop Test – VIDEO**

## **Slide 27 – Incremental Expansion of Human Exploration Capabilities (Roadmap to Mars)**

- The SLS and MPCV are being designed and developed to explore beyond LEO. Traveling to a Near Earth Asteroid, the Moon, Lagrange Points, and ultimately to Mars.
- As we explore beyond low Earth orbit and for increasing periods of time, there are several capabilities we must be able to support.
- NASA was challenged to reach a Near Earth Asteroid by the middle of the next decade and Mars by middle 2030s.
- These destinations require high thrust in-space propulsion, long duration habitation, surface capabilities, and advanced propulsion.
- We have defined six steps to get to Mars, which are numbered and displayed in gray.
  1. Enable New LEO Missions
  2. Enable Missions Beyond LEO
  3. Enable Lunar Surface Missions
  4. Enable Long Duration Missions
  5. Enable Deep Space Missions, moving from Long duration missions to the sixth step
  6. Enable Mars mission
- Between each step we must expand our existing capabilities and develop new capabilities to help with obtaining each goal.
- Careful planning is required for traveling to Mars.
- Our astronauts will be millions of miles from Earth and if something goes wrong, it will take more than a couple of days to return home.
- Of course this will all be a challenge, but as humans we need to explore and see what is out there.



## **Slide 28 – Commercial Crew Program**

- The U.S. National Space Policy released in 2010 states the United States is committed to enabling the commercial space industry through inventing nontraditional agreements, making the Government's technology and infrastructure available, and minimizing the regulatory burden for commercial space activities.
- NASA established the Commercial Crew Program to help implement the Space Policy.
- CCP is designed to manage commercial space activities that will develop and demonstrate human spaceflight capabilities. Our goal is to turn over transportation to LEO to our commercial partners, freeing NASA to explore the outer depths of our solar system.
- In April 2011, we awarded four Space Act Agreements (SAAs) as part of the CCDev2 (Commercial Crew Development, Round 2) effort, worth a total of \$269 Million.
- This phase will be completed by May 2012 and the companies must reach set milestones.
- Three unfunded SAAs have also been signed with other companies:
  - Alliance Techsystems (ATK)
  - United Launch Alliance (ULA)
  - Excalibur Almaz, which is not shown on the screen
- The next step for commercial crew is the Integrated Design Contract (IDC), which is the next opportunity to receive funds from NASA for the development of their spacecraft.
- We are committed to transporting American astronauts on American-made spacecrafts. These SAAs allow us to take advantage of American ingenuity to get to LEO, so NASA is able to focus on the future of deep space exploration.
- Part of this effort includes attracting businesses that will bring their entire life-cycle operations here, including launch, but we will talk about this a little later.

## **Slide 29 – Blue Origin**

- Received \$22 million as part of CCDev2.
- The Crew Transportation System is comprised of a reusable biconic space vehicle launched first on an Atlas V launch vehicle, then on Blue Origin's own Reusable Booster System.
- During CCDev2, Blue Origins is working to mature the space vehicle design through a Systems Requirement Review, mature the Pusher Escape System, and accelerate engine development for their Reusable Booster System.
- Future work includes a Pusher Escape Ground Firing and Reusable Booster System Engine Thrust Chamber Assembly Test.



### **Slide 30 –Boeing**

- Boeing was awarded \$92.3 million as part of CCDev2.
- Their commercial Crew Transportation System comprises the reusable CST-100 spacecraft, launch services, and ground systems.
- CST-100 is compatible with multiple launch vehicles, but Boeing has announced their intention to launch the first CST-100 flight on an Atlas V.
- The CST-100 capsule is reusable for up to 10 missions.
- During CCDev2, Boeing is working to mature their commercial crew transportation system through the preliminary design review and perform developmental tests.
- Boeing has been through several reviews, including the completion of Landing Air Bag Drop Demonstration #1.
- They are working toward an Orbital Maneuvering and Abort Control Hot Fire Test, among other milestones.

### **Slide 31 – Sierra Nevada Corporation**

- Sierra Nevada was awarded \$80 million as part of CCDev2.
- The Dream Chaser is a reusable, piloted lifting body derived from the NASA HL-20, and is planned to launch on an Atlas V.
- Sierra Nevada will fabricate an atmospheric flight test vehicle, conduct analysis and risk mitigation, and conduct significant hardware testing.
- During CCDev2, Sierra Nevada is working to mature the Dream Chaser crew transportation system design through a preliminary design review with some subsystems to critical design review.
- Sierra Nevada's accomplishments to date include opening their Vehicle Avionics Integration Laboratory that will allow them to test all avionic systems on the Dream Chaser.
- They are working toward several tests including a captive carry interface and landing gear test.



### **Slide 32 – SpaceX (Space Exploration Technologies)**

- SpaceX was awarded \$75 million in CCDev2.
- Their Crew Transportation System is based on the existing Falcon 9 launch vehicle and Dragon spacecraft, which have been designed since inception for crew carriage with relatively minimal modification.
- Both the longest-lead and most safety-critical system is the Launch Abort System (LAS).
- SpaceX is working to mature the flight-proven Falcon 9/Dragon transportation system focusing on developing an integrated, side-mounted LAS.
- When you look at who has launched a capsule into orbit and returned it to Earth, you have Russia, the United States, China, and now SpaceX. They are the only commercial company to do this, while it has taken three Government agencies.
- Their future work for CCDev2 includes LAS testing and a concept baseline review.
- SpaceX is also involved in the Commercial Orbital Transportation System, or COTS, program, which will eventually use commercial companies to fly resupply missions to the International Space Station.
- They flew their first flight on June 4, 2010, and their first COTS demonstration flight on December 8, 2010.
- They are planning to launch their second demonstration flight in January. This mission will demonstrate the ability to fly within close proximity to the International Space Station, and if it is successful with that objective, they will press ahead with docking to the Station, before returning to Earth.

### **Slide 33 – Unfunded Space Act Agreements**

- In addition to the four funded Space Act Agreements, there are also 3 companies working with NASA through unfunded Space Act Agreements. This means they are able to work with NASA, but do not receive money for their development.
- ULA is looking to review and evaluate the human certification plan for the Atlas V and mature the related design to a System Requirements Review.
- ATK is developing the Liberty Launch Vehicle, which includes an ATK five-segment solid rocket motor as a first stage. They are looking to mature the design of the Liberty through technical integration meetings and design reviews.
- Excalibur Almaz is advancing its commercial crew space transportation systems concepts with NASA's participation in milestone and technical review briefings and project status briefings provided in conjunction with milestone reviews.



### **Slide 34 – Partnering Capabilities**

- Enabling commercial spaceflight is very important, but we also believe it is important to establish relationships with those companies, as well as other countries, non-profit organizations, and the local community.
- This represents a major change in the way we do business, but it is a change that KSC and other NASA Centers need to make to achieve success.
- At KSC, the key to developing partners is our Center Planning and Development Office.
- Their mission is to retain KSC's highly trained aerospace workforce and facility assets by attracting new businesses to establish a presence on or near KSC.
- They are responsible for partnership development - identifying commercial and other government agency partnership opportunities.
- With all of our CCDev partners, we have established agreements to provide KSC engineering services, use of KSC facilities, and loan of government property.
- CPDO works with space-related industries, as well as service-related industries (e.g. those that process payloads, pack parachutes, etc.)
- Several other Centers have similar offices that are working to bring in commercial entities.
- One example of success for KSC is our partnership with Space Florida. We work closely with the state of Florida to attract commercial entities.
- At the end of October (October 31) KSC made a first-of-its-kind announcement about an agreement with Space Florida. This agreement allows them to use one of our Orbiter Processing Facilities, the Space Shuttle Main Engine Processing Facility, and the Processing Control Center.
- With the end of the Shuttle Program, we no longer have a need for this facility and we have worked a way to allow Space Florida to take over the facility to allow a commercial company to use the facility with no cost to NASA.
- We will actually save approximately \$9.1 million dollars that would have been spent on O&M, energy, demolition, etc.
- Boeing has signed an agreement with Space Florida to process their CST-100 capsule in the facility.
- As we identify other facilities that do not we do not have an immediate need for, there will be more agreements of this kind.

### **Slide 35 – International Partnership**

- I discussed the importance of commercial partnerships, but international partnerships will be incredibly important to our future as well.
- As mentioned earlier, the International Space Station would not be complete without the collaboration with our international partners.
- We have worked or are working with Argentina, Australia, Austria, Canada, Denmark, Eurpouse/ESA, France, Germany, India, Italy, Japan, Korea, The Netherlands, Norway, Russia, Spain, Sweden, Switzerland, and the United Kingdom, just to name a few.
- Focusing on partnerships between NASA and the UK, NASA and the UK Space Agency have signed a Statement of Intent.
- While no specific projects or missions are identified in the statement of intent, we are looking for potential areas of collaboration.
- These areas include:
  - Earth Science - Atmospheric chemistry, Climate Change, Ocean Processes
  - Space Sciences – Lunar/planetary science, astrophysics, heliophysics
  - Human and Robotic Space Exploration – Robotic pre-cursor missions, human exploration missions, Scientific utilization of the International Space Station
- Working together, we can accomplish amazing things.



## **Slide 36 – Conclusion**

- NASA is taking the next step in human exploration, beyond low Earth orbit.
- We have been going to low Earth orbit for the past 50 years and are using this experience to work with commercial companies to perform this function.
- This will free NASA resources to develop the systems necessary to travel to a Near Earth Asteroid, the Moon, Lagrange Points, and eventually Mars.
- At KSC, we are positioning ourselves to become a multi-user launch complex and everything we are working on is bringing us closer to achieving this goal.
- A vibrant multi-use spaceport is to the 21st Century what the airport was to the 20th Century – an invaluable transportation hub that supports government needs while promoting economic development and commercial markets beyond Earth's atmosphere.
- This past year saw the end of Shuttle, but the announcements of NASA's crew module, Orion, and heavy-lift rocket, the SLS, as well as the establishment of the Commercial Crew Program.
- We have a busy, but very bright future ahead of us and KSC is looking forward to playing an integral part in the next era of human space exploration.
- The future is SLS, 21st Century Ground Systems Program, and the Commercial Crew Program; and the future is here.
- Thank you for inviting me to be here.